Northern Illinois University

Typical use levels of personal listening devices of students at Northern Illinois University

A Thesis Submitted to the

University Honors Program

In Partial Fulfillment of the

Requirements of the Baccalaureate Degree

With Upper Division Honors

Department of

Communicative Disorders

By

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DeKalb, Illinois

August 12, 2006

University Honors Program

Capstone Approval Page

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HONORS THESIS ABSTRACT
THESIS SUBMISSION FORM

AUTHOR: Jennifer Stein

THESIS TITLE: Typical use levels of personal listening devices of students at Northern Illinois University

ADVISOR: Joseph Smaldino

ADVISOR'S DEPT: COMD

DISCIPLINE: 11. r. / fiW1to OS<:;

YEAR: ;)ootç

PAGE LENGTH: 11

BIBLIOGRAPHY: yes

ILLUSTRATED: nO

PUBLISHED (YES OR NO): tJl)

LIST PUBLICATION:

COPIES AVAILABL~'

MICROFILM, DISKETTE):

ABSTRACT (100 - 200 WORDS): 17.$

Abstract

A recent lawsuit filed against Apple Computers, Inc. has aroused public concern about the potential role of personal music players (MPs) in the development of hearing loss. In order to determine if such devices are used at levels likely to damage hearing, typical MP use levels were recorded from a sample of Northern Illinois University students. The average sound pressure level (Leq) was measured for each music sample. These levels were compared with National Institute for Occupational Safety and Health (NIOSH) recommendations for maximum daily noise exposure.

While previous research has indicatJ that MPs are capable of producing sound output levels that can damage hearing, from the data collected in the present study, it did not appear that the students were listening to their MPs at levels that were likely to cause noise-induced hearing loss. However, since the effects of noise exposure are cumulative it is possible that, when combined with exposure to other noise sources, the use of personal MPs could contribute to overall hearing loss. In addition, the majority of the students who volunteered their music players for use in this study were communicative disorders majors. Since it is likely that they were well informed about the risks of excessive noise exposure, it is possible that increased public awareness about such dangers will be of great benefit in preventing noise-induced hearing loss in the future.

Introduction

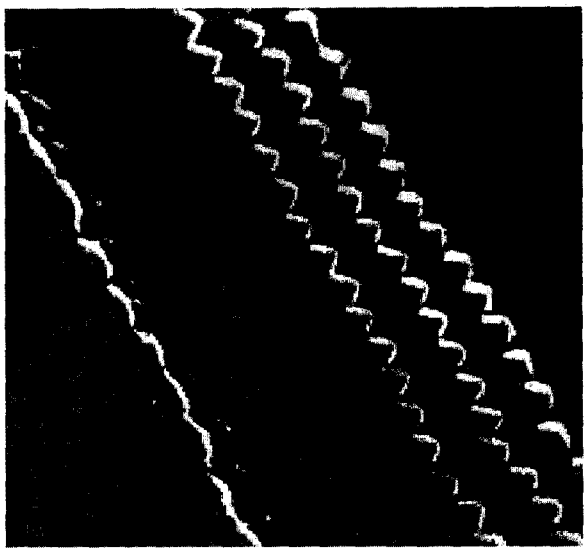
On January 31, 2006 John Kiel Patterson filed a class action lawsuit in a California court against Apple Computers, Inc. claiming that the company's iPod personal music players (MPs) are "inherently defective in design and are not sufficiently adorned with warnings regarding ... the onset of noise-induced hearing loss [NIHL], a condition which has no cure or treatment." (FindLaw, 2006) The lawsuit also claims that iPods are capable of producing sound output levels as high as 115 decibels (dB) and that they can cause hearing damage with exposure times as low as 28 seconds per day. While Apple has been forced to limit the output of iPods sold in Europe to 100 dB, it has not done the same in the United States meaning, says the lawsuit, that "millions of consumers have had their hearing put at risk by Apple's conduct." (FindLaw, 2006)

Noise exposure can affect the delicate hearing mechanism in several ways, dependent on the frequency, intensity and duration of the offending sound. The most detrimental effect of noise exposure is acoustic trauma, which occurs rapidly as the result of a brief, high-intensity sound such as an explosion. A sound of 140 dB or louder can cause the Organ of Corti and the basilar membrane, structures of the inner ear or cochlea, to be pulled apart, resulting in immediate, permanent hearing loss. The amount of mechanical damage to the cochlea depends mainly on the intensity of the noise as it reaches the ear (Fligor, 2006; Clark & Bolme, 1999; Kryter, 1994).

Exposure to less intense noise, approximately 85 - 130 dB, can produce a decrease in hearing sensitivity known as a noise-induced threshold shift (NITS). Most people have experienced a temporary threshold shift (TTS) after attending a concert or other noisy event. This decrease in hearing sensitivity is due to metabolic overload of the

sensory receptors of the cochlea, known as hair cells. A TTS feels like fullness or dullness of the ears, and it may be accompanied by tinnitus, or ringing in the ears. Hearing sensitivity generally returns to pre-exposure levels within hours or days, depending on the intensity and duration of exposure, as well as on individual susceptibility (Rabinowitz, 2000;Yost, 2000; Hellstrom et al., 1998; Kryter, 1994).

A decrease in hearing sensitivity that lasts more than four weeks is considered to be a permanent threshold shift (PTS) (Quaranta et aI, 1998). A PTS indicates that some of the hair cells have been damaged metabolically, due to repeated exposure to intense noise, and can no longer transduce acoustic stimuli into electrical signals. As a result, the frequencies that normally stimulate the damaged region of the cochlea can no longer be effectively transmitted to the brain. Because NIHL occurs gradually over months or years, it may go undetected until it is so severe that the individual begins having trouble understanding speech. Once the cochlear hair cells are destroyed, they do not regenerate and hearing sensitivity does not return to normal levels. (See Figures 1 and 2 below for a comparison of normal and damaged hair cells.) The effects ofNIHL are cumulative; the damage is compounded with each additional exposure to loud noise (DeBonis & Donohue, 2004; Rabinowitz, 2000; Yost, 2000; Clark & Bohne, 1999; Kryter, 1994). There is no cure for a sensorineural hearing loss such as NIHL.. While the individual can be fitted with a hearing aid to amplify sounds as they enter the ear, speech may still remain incomprehensible because changes have occurred in the way the ears code certain frequencies and send these to the brain (Henderson & Salvi, 1998).



www.hei.org

Figure 1-

Normal inner ear hair cells

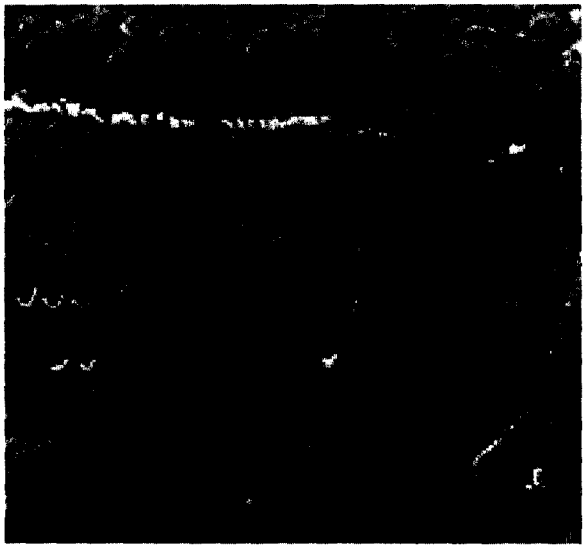


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Figure 2-

Inner ear hair cells damaged by noise exposure

According to the National Institute on Deafness and Other Communication Disorders (NIDCD), more than 30 million Americans are regularly exposed to hazardous sound and approximately 10 million Americans have a hearing loss that can be attributed, at least in part, to noise exposure. If the 42 million iPods that have been sold since the product's introduction in 2001 (Goodin, 2006) are contributing to this problem, the claims made in the above mentioned lawsuit indicate an important public health concern that must be addressed. Although NIHL is the second most common form of hearing loss, it is almost entirely preventable (Rabinowitz, 2000). While standards put in place by the Occupational Safety and Health Administration (OSHA) limit workers' unprotected occupational noise exposure to 90 dB for a maximum of 8 hours per day, no similar standards exist in the United States to protect individuals from excessive exposure to MPs, such as iPods, and other forms of recreational noise. Because of this lack of regulation, public education about the effects of noise on hearing, as well as strategies for hearing loss prevention, is essential..

Research indicates that MP sound output levels at maximum volume setting may range from 91-121 dB, depending both on the model of MP and the type of headphone used. Clearly, listening to MPs at these levels has the potential to cause NIHL (Fligor, 2006; Fligor & Cox,2004; Mostafapour et al, 1998). However, the risk ofNIHL depends, not on the maximum volume setting, but on the level at which the MP is actually used. The purpose of this research project is to measure and record typical use levels ofMPs from a sample of Northern Illinois University students and to determine if these levels are likely to damage the listener's hearing.

Methods

Five students volunteered their MPs for use in this study. All students were asked to put their MP at their preferred listening level. Measurements were taken in a quiet classroom. The MPs were placed on the Probe Test Ear II (MSP Communications, Inc.), which has a resonance curve similar to that of a human ear. Measurements were taken using Etymotic Research ER-7C Probe Mic System and Larson Davis Laboratories Model 800B Precision Integrating Sound Level Meter. Measurements were made in A-weighted decibels, meaning a filter was used that more heavily weights the frequencies between 1000 to 4000 Hz to which human hearing is more sensitive (Rabinowitz, 2000; Clark & Bohne, 1999; Kryter, 1994). The equivalent sound level (Leq), which is the average sound pressure level (in dB) that is produced by a fluctuating sound source over a specified period (Fligor & Cox, 2004), was measured for each one-minute music sample played. These measurements were then compared with Occupational Safety and Health Administration (OSHA) and National Institute on Occupational Safety and Health (NIOSH) recommendations for maximum noise exposure. In addition, the low, high and peak sound pressure level was measures. Because the volume control setting increments varied from system to system, volume setting was recorded as percent of maximum so that they systems could be more easily compared.

Results

The students in this study had the volume set at between 48 -67 % of their MPs maximum volume. At these settings, the peak sound pressure level for the samples measured range from 92.4 - 97.9 dB, and the Leq ranged from 66 -79.3 dB. The

following formula (from Fligor & Cox, 2004) was used to determine the maximum time of exposure (T) at a specific decibel level (L).

$$T = 480 / 2^{(L - 85)/3}$$

In this formula, the number 85 represents the maximum recommended exposure level in dB, and 480 is the number of minutes of exposure permitted at this level. The number 3 is the exchange rate (Fligor, 2006: Fligor & Cox, 2004; NIOSH, 1998). The results of the measurements and calculations made are summarized in Figure 3 below.

Figure 3- Typical MP use levels

System	Headphone type	Volume (% of max)	Leq (dBA)	Low (dBA)	High (dBA)	Peak (dBA)	Permitted daily exposure
iPod nano	Intra-aural	50%	77.2	65	81	95.9	>24 hrs
Creative Zen Neeon	Supra-aural	65%	74.4	68.3	79.4	94.8	>24 hrs
Samsung Digital Audio Player	Intra-aural	67%	79.3	76.8	82.5	97.9	>24 hrs
Creative Nomad Jukebox Zen Xtra	Supra-aural	48%	72.6	62	77.5	92.4	>24 hrs
Creative MUVOTXFM	Supra-aural	50%	66.0	54.5	71.8	94	>24 hrs

Discussion

Previous research indicates that NIHL is a common problem, particularly among teens and young adults. A 1998 study by Mostfapour et al. found evidence ofNIHL in nearly one-third of the college students they tested. Another study found a statistically significant increase in hearing thresholds among individuals aged 18 - 30 years who used personal MPs for more that 7 hours per week (Meyer-Bisch, 1996). One survey found more than half of high school students to have at least one symptom ofNIHL (Shafer, 2006). While MPs are not likely to be the sole cause of this problem, a study by Catalano and Levin (1985) found that, of 190 college students who were studied, 31 % met or exceeded the maximum permitted daily noise dose permitted and were likely to develop NIHL..

From the data collected, it did not appear that the students in the present study were listening to their MPs at levels that were likely to cause NIHL.. However, several confounding factors may have influenced these results. First, the sample size was small and, of the 5 students who volunteered their MPs for use in the project, 4 were students of communicative disorders. It is likely that this group of students was more knowledgeable about the effects of noise on hearing than the average college student, and this knowledge may have contributed to their moderate listening levels. It is possible that research data collected from a larger, more randomly selected sample of students may yield different results. However, this finding may also indicate that education, rather than legislation, may be the best way to prevent NIHL.

Secondly, due to difficulty in getting a project using human subjects approved it was not possible to collect any personal data about the students whose MPs were used in

this study. Future research should include not only include more subjects, but also collect data about the participants' time of daily MP use, symptoms ofNIHL, and exposure to other recreational or occupational noise sources or ototoxic substances. Only by obtaining all this information would it be possible to determine if MP use, when combined with these other factors, is contributing to NIHL in any particular case.

Also, it is important to keep in mind that, while the average SPL produced by the MPs at the listening levels found here did not seem to be sufficient to produce NIHL alone, the peak levels of the MPs may have the potential to cause acoustic trauma if superimposed over a background of continuous noise (Fligor & Cox, 2004). In addition to damaging the auditory system, excessive noise exposure has also been linked to negative effects on mental, cardiovascular, respiratory, and gastrointestinal health. It can also disrupt sleep, even after the noise stops, increase fatigue and irritability and cause difficulty in concentration (ASHA, 2002; Kryter, 1994).

When determining safe exposure times at specific sound levels, it is important to remember that the decibel scale is logarithmic, rather than linear. Sound pressure level in computed by using the formula

Sound pressure level (SPL) = 20 log (pressuremeasurcd/pressurereferencc)

where the reference pressure equals 20 micropascals. Using this formula, we can determine that for each 3-dB increase in SPL, the sound intensity is doubled. Put another way, for each 3-dB increase in sound intensity, exposure time should be halved. For this

reason, NIOSH recommends the following maximum allowable listening times per day to avoid NIHL..

Figure 4- Permissible Noise Exposures

Duration (Per day)	**Sound level [dB(A)]**
25 hours 24 minutes	80
16 hours	82
8 hours	85
4 hours	88
2 hours	91
1 hour	94
30 minutes	97
15 minutes	100
7 minutes 30 seconds	103
3 minutes 45 second	106
1 min 52 seconds	109
56 seconds	112
28 seconds	115

(Adapted from NIOSH, 1998)

While the individuals in this study did not appear to be damaging their hearing with their MPs, based on these exposure times and levels it appears that the claims made

in the above mentioned lawsuit have some merit. Since cochlear damage, once done is likely to be permanent, prevention is the key. Individuals should limit their combined daily exposure times to all noise sources accordingly. If this is not possible, hearing protection, such as specially designed ear plugs or earmuffs should be used to reduce the effects of noise exposure. Because damage to the inner cannot be seen and the effects of NIHL generally occur gradually, persons at risk should be alert to the warning signs, such as tinnitus, feelings of fullness or pressure in the ears, and difficulty understanding speech. Anyone who is concerned about their hearing should be evaluated by an audiologist. .

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